Integration of Daily Inundation Extent Estimates into an Ecosystem-Atmosphere Gas Exchange Model

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Atmospheric and Environmental Research

Objective

- Integrate near-daily remotely-sensed inundation maps (from **SMAP**) with an ecosystem process model (**DLEM**) to produce more accurate greenhouse gas emission estimates (e.g., **CH_4**)

Method Development

- Derive inundation from AMSR-E footprint-matched time series (SMAP analog)
  - Lower resolution than SMAP (37 vs. 3-9 km)
  - Higher errors in vegetated areas than SMAP (e.g., dry bias)
- Model daily CH_4 flux from subgrid types separately, e.g. run DLEM with 100%:
  - Inundated/saturated wetland (excluding masks)
  - Non-wetland (from local land cover; excluding masks)
  - Subsaturated wetland (e.g., 75%, 90%, 95% saturated; planned for future work)
- Model daily mixed grid cell CH_4 flux from composite cells, e.g.:

  CH4 = f(wetland)*CH4(wetland) – [1-f(wetland)]*CH4(non-wetland)

SMAP

Soil Moisture Active Passive Mission

- Launch expected Nov. 2014
- 39x47 km L-band (~1.4 GHz) microwave radiometer
- ~3 km L-band synthetic aperture radar (SAR)
- 2-3 day revisit period
- Potential for inundation mapping
  - 3-9 km resolution
  - Water detection or water fraction retrieval
  - Better under-canopy water detection (than higher frequencies)
  - Better detection skill using time series (than less frequent datasets)

DLEM

Dynamic Land Ecosystem Model

- Quantifies regional GHG fluxes (including CH4, CO2, N2O) daily given atmospheric forcing (including precipitation) (Tian et al., 2010)
- ¼° resolution with subgrid land cover
- Models soil saturation but not dynamic inundation extent
- Baseline model: Wetlands extents externally prescribed from monthly wetlands coverage data (e.g., Papa et al., 2010)

Acknowledgment

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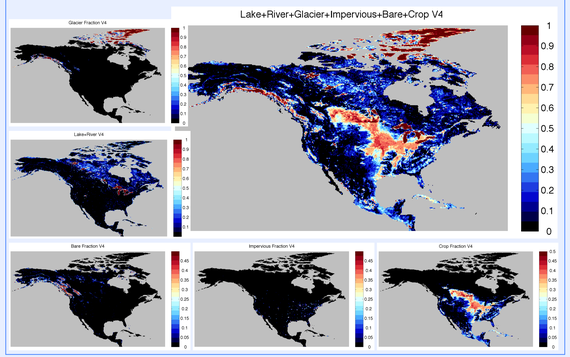
1993-2004 water cover data provided courtesy of C. Prigent (Prigent et al., 2001, 2007; Papa et al., 2010).

Static Land Cover

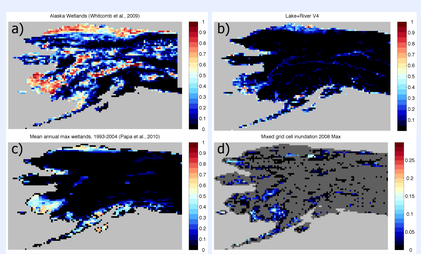
- CH_4 emission depends on what land cover types are inundated



Static and dynamic wetland inundation

Data needs for GHG modeling:

1. High quality, high resolution (~100 m) wetlands, open water, and other land cover type (e.g., Whitcomb et al. 2009)
2. Frequent estimates of inundated and saturated fraction
3. 1+2 combined: Fractions of wetlands and other land cover types that are inundation/saturated. CH_4 emission is highest where wetlands ecosystem types are inundated or saturated.



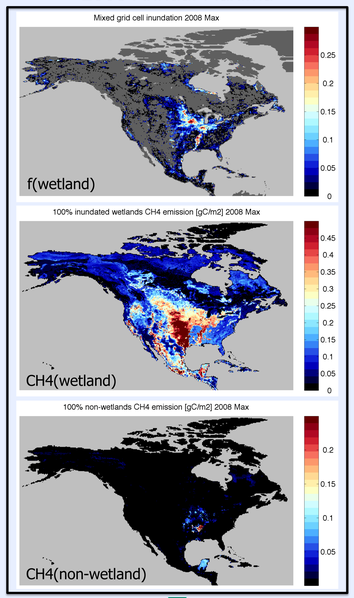
Examples of Alaska wetlands and water cover in 1/4° grid:
a) Wetlands, ~100 m (JERS-1, Whitcomb et al. 2009)
b) Lakes and rivers, ~250 m (MODIS, SRTM, and others combined for this work)
c) Mean annual inundation 1993-2004, ~70 km (multisatellite, Papa et al. 2010)
d) Maximum inundation 2008, ~37 km (AMSR-E; derived in this work and currently being calibrated/validated)

Mixed Grid Cell CH_4 Emission

- Mixed grid cell CH4 flux [gC/m^2/day]:

  CH4 = f(wetland)*CH4(wetland) – [1-f(wetland)]*CH4(non-wetland)

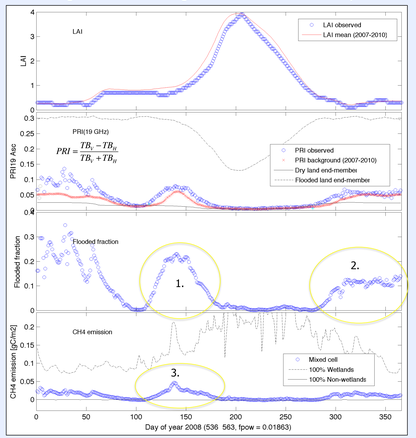
2008 Annual Maxima



- F(wetland): includes permanent wetland (2007-2010) and daily inundation; excludes permanent open water.
- CH4 emission to be validated with CH4 concentration measurements and WRF/STILT Lagrangian particle dispersion model

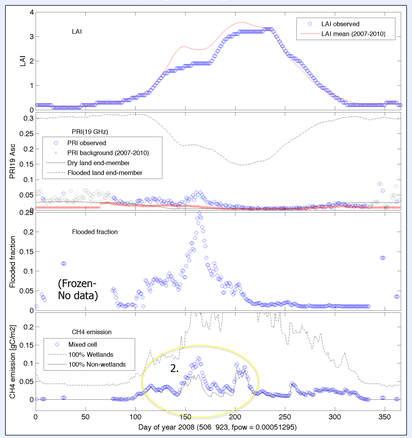
Time Series Analyses

Agricultural flooding in the Sacramento Valley



1. Pattern of April-May-June flooding observed in all years (2007-2010)
2. Irregular flooding observed in winter
3. Flooding is the source of all CH_4 emission (i.e., zero non-wetland emission)

Spring flooding in Iowa



1. May-June 2008 flood events affected large areas of the Midwest
2. CH_4 emission comes mostly from saturated/near-saturated, non-wetland areas of the cell, which dominate flooded areas even during peak flood extent

Conclusions and Future Work

- High quality, high resolution (<100 m) wetlands and open water land cover data are needed for continental-scale ecosystem emission modeling with remotely-sensed inundation forcing
- SMAP's higher resolution (~3-9 km), lower-frequency time series data should allow for more localized and more sensitive (e.g., in vegetated areas) inundation estimates
- Ongoing work in preparation for SMAP includes: 1) development of downscaling methods to better specify the fractions of inundated land cover types and 2) cal/val of AMSR-E inundation methodology for use as a SMAP analog and precursor dataset

References

Entekhabi, D., et al. (2010), The soil moisture active passive (SMAP) mission, *IEEE Int. Geosci. Rem. Sens. Sym.*, 98(5), 704-716.

Papa, F., C. Prigent, C. Jimenez, F. Aires, and W. B. Rossow (2010), Interannual variability of surface water extent at global scale, 1993-2004, *J. Geophys. Res.*, 115, D12111, doi:10.1029/2009JD012674.

Prigent, C., E. Matthews, F. Aires, and W. B. Rossow (2001), Remote sensing of global wetland dynamics with multiple satellite data sets, *Geophys. Res. Let.*, 28 , 4631-4634.

Prigent, C., F. Papa, F. Aires, W. B. Rossow, and E. Matthews (2007), Global inundation dynamics inferred from multiple satellite observations, 1993-2000, *J. Geophys. Res.*, 112, D12107, doi:10.1029/2006JD007847.

Tian, H., X. Xu, M. Liu, W. Ren, C. Zhang, G. Chen, and C. Lu (2010), Spatial and temporal patterns of CH4 and N2O fluxes in terrestrial ecosystems of North America during 1979–2008: application of a global biogeochemistry model, *Biogeosciences*, 7, 2673-2694, doi:10.5194/bg-7-2673-2010.

Whitcomb, J., M. Moghaddam, K. McDonald,J. Kellndorfer, and E. Podest, Mapping wetlands of Alaska from L-band SAR imagery, *C. J. Remote Sensing*, vol. 35, no. 1, pp. 54-72, February 2009.